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[Title of the Invention] Injection Apparatus for MRI

[Abstract]

[Purpose]

To prevent magnetically adverse effects of an injection apparatus for MRI by preventing a generation of magnetic field and an interference of electromagnetic noise.

[Construction]

The injection apparatus for MRI comprises: means for employing an ultrasonic rotary motor as its driving source; means for employing a battery as its power source; and optical connector means provided on a cable for connecting a device provided within an electromagnetic shield room to a control unit for controlling the device from the outside of the electromagnetic shield room.

[What is claimed is]

[Claim 1]

An injection apparatus for MRI (Magnetic Resonance Imaging) comprising:

means for employing an ultrasonic rotary motor as its driving source;

means for employing a battery as its power source; and

means for providing optical connectors on a cable for connecting a device provided within an electromagnetic shield room to a control unit for controlling the device from the outside of the electromagnetic shield room,

wherein the optical connectors provide for connection via a monitoring window glass provided on the electromagnetic shield room thereby to prevent magnetic field generation and electromagnetic noise interference in the electromagnetic shield room.

[Detailed description of the Invention]

[0001]

The present invention relates to an injection apparatus for MRI (magnetic resonance imaging).

[0002]

[Prior Art]

The imaging diagnostic technology using MRI is now widely employed for diagnoses of brains and hearts. Further, a method in which the imaging is performed with a contrast medium being injected to a patient is also widely used to obtain a clear MRI image. Fig. 3 is a diagram illustrating one exemplary construction of a recent typical MRI diagnostic system. In this figure, there are shown an electromagnetic shield room 1, an MRI magnet 2, a table 3 on which a patient lies, an injection device 4, a reservoir 5 for retaining a contrast medium, a monitoring window glass 6 made of a magnetic shield glass, an MRI control unit 7, an injection device control unit 8, connector cables 9 and 10, and an operator 11.

[0003]

The MRI diagnostic system which has a construction as shown in Fig. 3 and is adapted for formation of a magnetic image is entirely installed in the electromagnetic shield room 1, and the MRI power cable 9 is connected to the MRI system via a magnetic shield filter (not shown) so that the MRI system in not affected by electromagnetic waves. In a conventional practice, the injection of the contrast medium is manually performed by a doctor. This operation requires a careful attention for repeated high pressure injection. For alleviation of such a burden to the doctor, automatic injection with the injection device 4 has recently come in use. More specifically, the injection device 4 is designed so that a syringe pushing and pulling operation is performed by a motor in the same manner as the doctor does. The piston of the syringe is pulled to introduce the contrast medium into the syringe from the reservoir 5, and then the piston is pushed in the syringe to inject the contrast medium to the patient. This operation is automatically repeated.

[0004]

However, the injection device 4 which employs the motor magnetically adversely affects the MRI system to form an artifact in a diagnostic image. To solve this problem, the applicant of the present invention disclosed an injection apparatus which is adapted to prevent the magnetically adverse effect with the use of an ultrasonic motor in Japanese Patent Application No. 3-136971 entitled "Medical Injection Apparatus" and filed on May 14, 1991.

[0005]

[Problem to be Solved by the Invention]

As described above, the applicant of the present invention previously filed the patent application concerning the injection apparatus which is adapted to eliminate the magnetically adverse effect with the use of an ultrasonic motor. The prior art injection apparatus employs a commercial power source as its driving power source, and uses the ordinary cable 10 to connect the device 4 to

the control unit 8 for controlling the device 4 as shown in Fig. 3. These components generate fluxes to form an artifact in a diagnostic image.

[0006]

To solve the aforesaid problem, it is an object of the present invention to provide an injection apparatus for MRI which prevents a motor, a driving power source and control signal transmitting means thereof from producing magnetically adverse effects.

[0007]

[Means for Solving the Problem]

In accordance with the present invention, the injection apparatus for MRI comprises means for employing an ultrasonic rotary motor as its driving source, means for employing a battery as its power source, and means for employing optical connectors as its control signal transmitting means.

[0008]

[Embodiments]

Embodiments of the present invention will hereinafter be described with reference to the attached drawings. Fig. 1 is a diagram illustrating the construction of an injection apparatus according to one embodiment of the present invention. In the figure, there are shown an injection device 4, a monitoring window glass 6, an injection device control unit 8, cables 10a and 10b, and optical connectors 20a and 20b. The injection device 4 includes a cylinder 40, an actuator 41 fixed to a piston of the cylinder for sliding the piston in the directions of the arrows, an ultrasonic rotary motor 42, a driving mechanism 43, a battery 44 and a control circuit 45.

[0009]

The injection apparatus of the present invention has a construction as shown in Fig. 1, and uses the ultrasonic rotary motor 42 as a motor for driving the injection device 4 installed in an electromagnetic shield room 1 to prevent the

formation of an artifact in a diagnostic image which may otherwise result from the generation of a magnetic field as in the case of the conventional apparatus which uses a magnetic motor. In the present invention, the battery 44 is used as the driving power source for prevention of an electromagnetic noise which may otherwise be produced by the commercial power source. Thus, there is no need to connect the injection device 4 to a power source cable extending from the outside, thereby eliminating the flux from the power source cable. However, the control signal connection cable 10 extending from the outside injection device control unit 8 cannot be eliminated because of the construction of the injection apparatus. Therefore, the cable 10a within the shield room 1 is connected to the cable 10b via the optical connectors 20a and 20b for prevention of interference by the outside electromagnetic noise. Thus, the optical connectors serve to block the electromagnetic noise.

[0010]

In the MRI diagnostic system, the electromagnetic shield room 1 is provided with the monitoring window 6 such as comprised of a magnetic shield glass 6 as shown in Fig. 1, and the optical connectors 20a and 20b provide for connection via the glass 6. Thus, intrusion of the electromagnetic noise into the electromagnetic shield room 1 is prevented which may otherwise be caused by the cable 10a.

[0011]

Fig. 2(A) is a diagram illustrating one example of the optical connectors to be used in the present invention. In the figure, there are shown the cable 10a provided in the electromagnetic shield room 1 for connection to the injection device 4, the outside cable 10b for connection to the control unit 8, the optical connector 20a provided inside the shield room, the optical connector 20b provided outside the shield room, phototransistors 201a, 202a, ..., 20na provided in the optical connector 20a, and light emitting diodes 201b, 202b, ..., 20nb provided in

the optical connector 20b. When the light emitting diode 201b emits light, for example, the phototransistor 201a receives the light, which is converted into an electrical signal to establish an "ON" state as one informative indication.

[0012]

Exemplary control information required for the control of the injection device 4 of this type include "ON/OFF of the power source", "setting of an injection rate (slide rate of the actuator", and "setting of an injection pressure". For the ON/OFF control information, for example, the light emitting diode 201b and the phototransistor 201a are used in pair. If the "setting of the injection rate" is five-level setting, five pairs 202 to 206 are used. If the "setting of the injection pressure" is five-level setting, five pairs 207 to 211 are used. Thus, 11 light emitting diode/phototransistor pairs, in total, are used in combination for the optical connectors 20a and 20b.

[0013]

Fig. 2(B) is a diagram illustrating another example of the optical connectors to be used in the present invention. In the figure, the same reference characters as in Figs. 1 and 2 denote the same or equivalent components, and there are shown a bit signal modulation transmitting circuit 22, a light emitting diode 23, a phototransistor 24, and a bit signal demodulation receiving circuit 25. In this embodiment, the optical connectors use 5-bit digital signals, and are adapted to transmit control information indicative of the "ON/OFF of the power source", the "setting of the injection rate" and the "setting of the injection pressure" by using the light emitting diode 23 and phototransistor 24 in pair.

[0014]

More specifically, the bit signal modulation transmitting circuit 22 is comprised of IC-TC9132P, for example, and adapted to modulate a 38kHz carrier frequency into a five-bit signal on the basis of the control information from the injection device control unit 8 and actuate the light emitting diode 23 to transmit

the signal as an optical signal to the phototransistor 24. Upon receipt of the signal, the phototransistor 24 converts the signal into an electrical signal, which is amplified for demodulation by the bit signal demodulation receiving circuit 25 and then subjected to wave shaping by a Schmitt circuit. The resulting signal is converted into a command code by a data decoder, and the command is inputted into the control circuit 45. With this arrangement, only one light emitting diode/phototransistor pair is used. Where a remote control operation is performed with the use of an infrared ray, there is, of course, no need to bring the optical connectors, i.e., the light emitting diode 23 and the phototransistor 24, into contact with the glass 6.

[0015]

[Effects of the Invention]

As described above, the injection apparatus for MRI according to the present invention, which comprises the means for employing the supersonic rotary motor as its driving power source, the means for employing the battery as its driving power source, and means for employing the optical connectors as its control signal transmitting means, is effective in that a magnetic field or magnetic flux which may otherwise be generated by the driving mechanism, the power source and the control unit is prevented from magnetically adversely affecting the MRI.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a diagram illustrating the construction of an injection apparatus according to one embodiment of the present invention.

[Fig. 2]

Fig. 2 is diagrams illustrating exemplary optical connectors to be used in the present invention.

[Fig. 3]

Fig. 3 is a diagram illustrating an exemplary construction of an MRI diagnostic system.

[Description of Reference Numerals]

4 Injection device

6 Monitoring window glass

8 Injection device control unit

10a,10b Cables

20a,20b Optical connectors

22 Bit signal modulation transmitting circuit

23 Light emitting diode

24 Phototransistor

25 Bit signal demodulation receiving circuit

40 Cylinder

41 Actuator

42 Ultrasonic motor

43 Driving mechanism

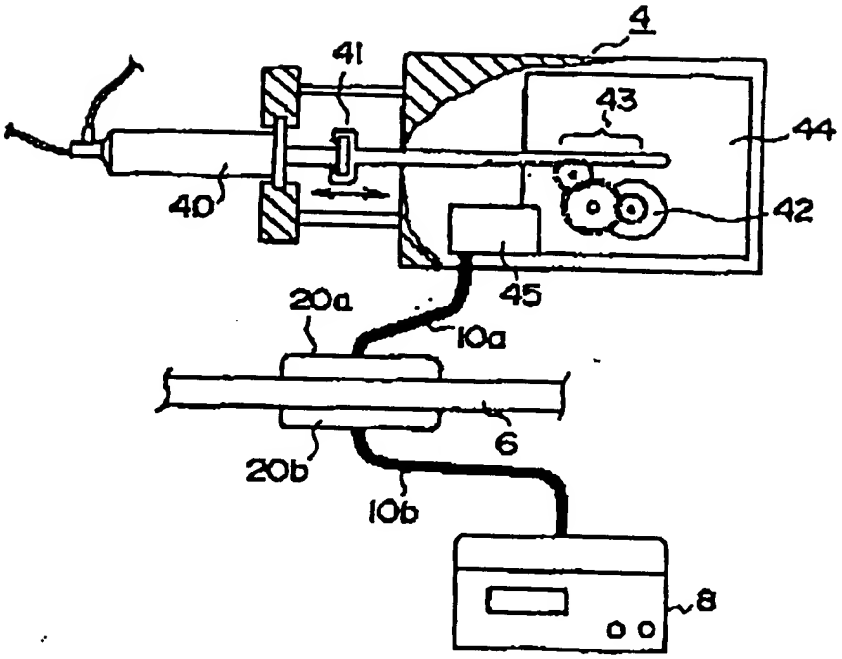
44 Battery

45 Control circuit

201a,202a Phototransistor

201b,202b Light emitting diode

FIG. 1 【図1】



4 : Injection Device

6 : Monitoring Window Glass

8 : Injection Device Control Unit

10a, 10b : Cables

20a, 20b : Optical Connectors

40 : Cylinder

41 : Actuator

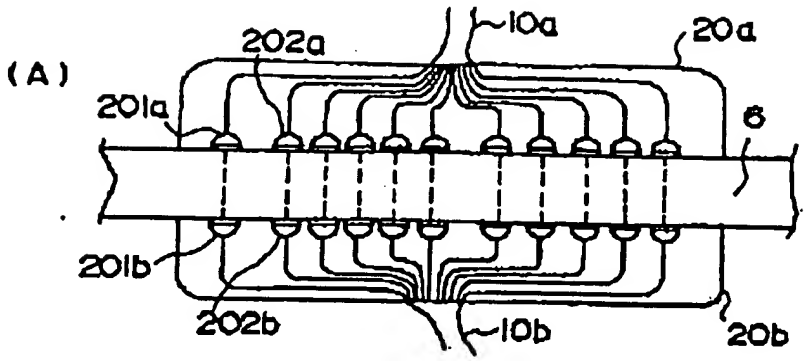
42 : Ultrasonic Motor

43 : Driving Mechanism

44 : Battery

45 : Control Circuit

FIG. 2 【図2】



201a, 202a : Phototransistor

201b, 202b : Light Emitting Diode

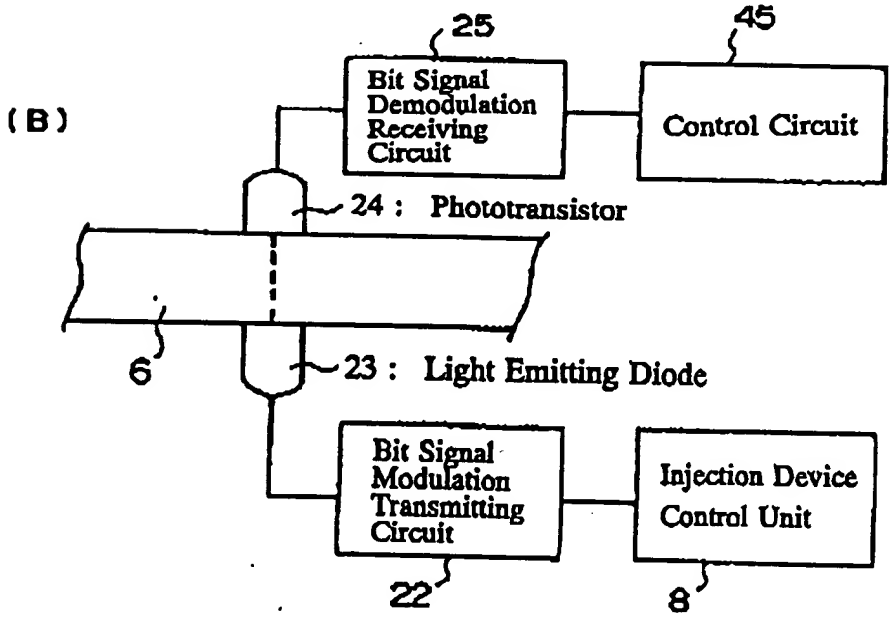
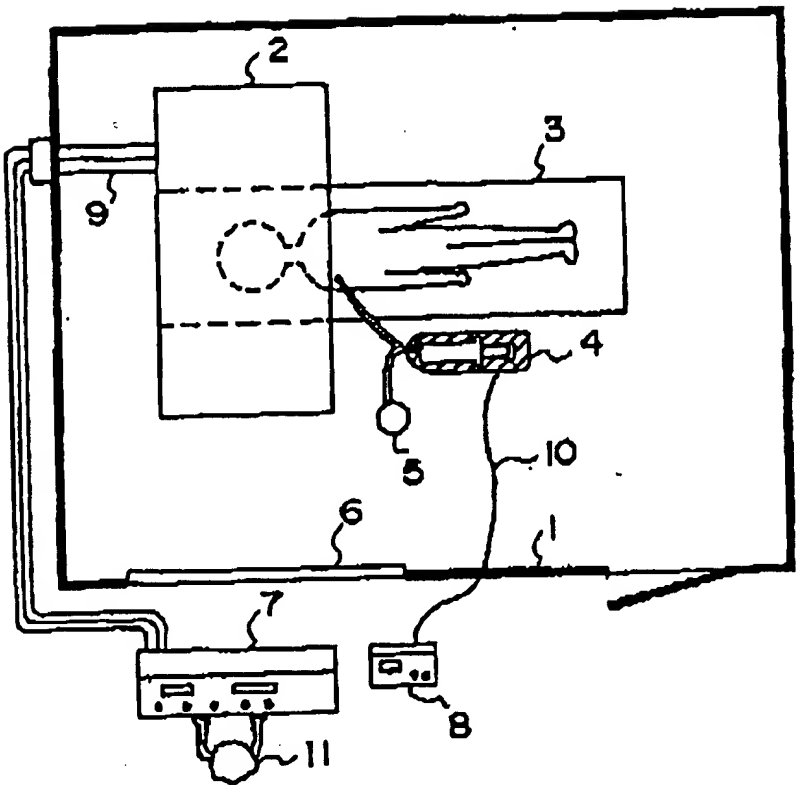


FIG. 3 【図3】



1 : Electromagnetic Shield Room
2 : Magnet
3 : Table
4 : Injection Device
5 : Reservoir
6 : Monitoring Window Glass
7 : MRI Control Unit
8 : Injection Device Control Unit
9, 10 : Cables
11 : Operator